

Effects of Pesticides and Fungicides Used on Grapevines on the Mealybug Predatory Beetle *Nephus 'boschianus'* (Coccinellidae, Scymnini)

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The effects of frequently used grapevine insecticides and fungicides on adults of the predatory beetle *Nephus 'boschianus'* of vine mealybug, *Planococcus ficus* (Signoret), were determined under laboratory conditions. When applied as cover sprays the pesticides chlorpyrifos, endosulfan, cypermethrin, chlorfenapyr and mercaptothion were very toxic to the predator, whilst the fungicides penconazole, foseetyl-Al, mancozeb and an insecticidal soap plus oil mixture were harmless. These results suggest that the insecticides may be harmful to a biological control system where *N. 'boschianus'* populations were dominant during the season. The three fungicides and the soap plus oil mixture, however, should be compatible with biological control by *N. 'boschianus'*.

Integrated grape production in South Africa currently mainly includes pesticides for the control of key pests such as vine mealybug, *Planococcus ficus* (Signoret), the weevils *Phlyctinus callosus* (Schönherr) and *Eremnus cereal* (Marshall), and the fruit flies, *Ceratit* *rosa* (Karsch) and *C. capitata* (Wiedemann). Additionally, preventative spray programmes against the fungal diseases, i.e. powdery mildew, *Uncinula necator* (Schwein) Burrill, downy mildew, *Plasmopara viticola* (Berk & Curt

Berlese & De Toni, *Botrytis cinerea* Pers.: Fr. and *Phytophthora cinnamomi* Rands are also applied in commercial vineyards. With increased focus on integrated pest management (IPM), organic production and more stringent export requirements regarding insecticide residues on fruit, the use of natural enemies will become more essential. This is particularly applicable in the case of *P. ficus*, as this insect can successfully be suppressed by biological control (Myburgh *et al.*, 1973). The effect of natural ene-

TABLE 1

Pesticides¹ and fungicides² screened for detrimental effects on the mealybug predatory beetle *Nephus 'boschianus'*. Formulations, field concentrations, pests/diseases targeted and range of concentrations tested are included.

Chemical tested (Trade name)	Formulations	Field concentration	Pest/disease targeted	Range of concentrations tested: mL/100L, g/100L
chlorpyrifos ¹ (Chlorpyrifos)	EC, 480g/L	100mL/100L 200mL/100L 400mL/100L	<i>Planococcus ficus</i> (mealybug) <i>Formicidae</i> (ants)	800; 400; 200; 100; 50; 20; 10; 5; 2.5; 1; 0.2; 0.04; 0.008
endosulfan ¹ (Endosulfan)	SC, 475g/L	125mL/100L	<i>Colomerus vitis</i> (erino	125; 62.5; 31.25; 15.62; 7.81
cypermethrin ¹ (Cypermethrin)	EC, 200g/L	10mL/100L	<i>Phlyctinus callosus</i> , <i>Eremnus cereal</i> (weevils)	200; 100; 50; 25; 12.5; 6.25; 3.13; 1.56; 0.78; 0.39
chlorfenapyr ¹ (Hunter)	SC, 360g/L	35mL/100L	<i>Frankliniella</i> <i>occidentalis</i> (thrips)	132.89; 88.59; 59.06; 39.38; 35; 26.25; 17.5; 8.75; 4.38; 2.19
mercaptothion ¹ (Malasol)	EC, 500g/L	175mL+8kg sugar or protein hydrolysate/100L	<i>Ceratit</i> <i>rosa</i> , <i>C. capitata</i> (fruit flies)	393.75; 262.5; 175; 116.67; 77.78; 51.85; 34.85; 23.04; 15.36; 10.24; 6.83; 4.55; 3.35; 3.03; 2.33; 2.02; 1.94; 1.62; 1.35
soap plus oil ¹ (Super insecticidal soap + Spraytech oil)	10mL/2mL	200g/100L	<i>Planococcus ficus</i> (mealybug)	1280; 640; 320; 160; 80; 40; 20; 10; 5
mancozeb ² (Mancozeb)	WP, 800g/kg	200g/100L	<i>Plasmopara viticola</i> (downy mildew)	3200; 1600; 800; 400; 200
penconazole ² (Topaz)	EC, 100g/kg	30-45mL/100L	<i>Uncinula necator</i> (powdery mildew)	23040; 11520; 5750; 2880; 1440; 700; 360; 180; 90; 45

mies such as the previously undescribed *Nephus 'boschianus'* (Whitehead pers. com, 2000) can be optimised by using chemicals that have little or no effect on them. The effect of six insecticides and three fungicides was therefore evaluated to identify those suitable for use in an IPM programme.

MATERIALS AND METHODS

Nephus 'boschianus' was reared on *P. ficus* cultures under controlled conditions. A range of concentrations (some of which 'range finder' concentrations) of commercial formulations of nine chemicals was used (Table 1).

Assays with each chemical included a control of distilled water. The bioassays were conducted in Munger cells as described by Hassan (1992). The pesticides were sprayed onto glass plates using a standard Potter's precision spray tower. The glass plates were allowed to dry for 10 min, after which the Munger cells were assembled and 50 adult *N. 'boschianus'* introduced into the cells. All Munger cells were ventilated with air at 70 to 80 % relative humidity and kept in a cooled incubator at $24.5 \pm 1^\circ\text{C}$. Mortality was recorded after 48 h. Data were analysed using probit analysis (Finney, 1952) and the computer programme, POLO PC (LeOra Software 1987, 1119 Shattuch Avenue, Berkeley, California 94707).

RESULTS AND DISCUSSION

Analysis of data concluded that the slopes for all chemicals, except fosetyl-Al, were positive. This indicated that there was an increase in mortality with an increase in concentration, except in the case of fosetyl-Al (Table 2; Figs. 1, 2 & 3).

The indices of significance for potency estimation (*g*) for the insecticides chlorpyrifos, cypermethrin, chlorfenapyr, and the mercaptothion bait mixture were considerably less than 1 (chlorpyrifos 0.098; cypermethrin 0.14; chlorfenapyr 0.29; mercaptothion 0.06). Therefore, the estimates of the fiducial limits of the

TABLE 2

Probit regression parameters estimated from bioassay data using nine chemicals on *Nephus 'boschianus'*.

Pesticide	Intercept ("Standard error)	Slope ("Standard error)	D.F.
chlorpyrifos	-0.5(±0.68)	5.4(±0.66)	12
endosulfan	2.97(±0.34)	1.59(±0.23)	4
cypermethrin	4.89(±0.09)	1.08(±0.1)	9
chlorfenapyr	-0.29(±0.5)	3.48(±0.32)	9
mercaptothion	2.74(±0.23)	6.86(±0.64)	18
soap plus oil	2.12(±0.52)	0.45(±0.21)	8
mancozeb	-61.78(±8670568) ^x	18.38(±2473665) ^x	4
fosetyl-Al	-3.35(±9730454) ^x	1.59-14(±3064902) ^x	4
penconazole	2.3(±0.41)	0.44(±0.12)	9

^xData not reliable for determination of LC_{50} and LC_{90} .

LC_{50} (concentration at which 50% of included individuals are killed) and LC_{90} values were reliable (Finney, 1952) (Table 3).

In the case of penconazole ($g=2.67$) and the soap plus oil mixture ($g=8.4$), the *g* values were greater than 1. Therefore, although the LC_{50} and LC_{90} values were estimated, estimates of the fiducial limits could not be made (Finney, 1952) and are not given. As no correlation between concentration and mortality was evident for mancozeb and fosetyl-Al, no attempts were made to estimate the LC_{50} and LC_{90} values for these pesticides.

The two field concentrations of chlorpyrifos and the field concentration for the mercaptothion EC bait mixture (Table 3; Fig.1) were considerably higher than the LC_{50} and LC_{90} for these pesticides, making them the most toxic of those tested on *N. 'boschianus'*.

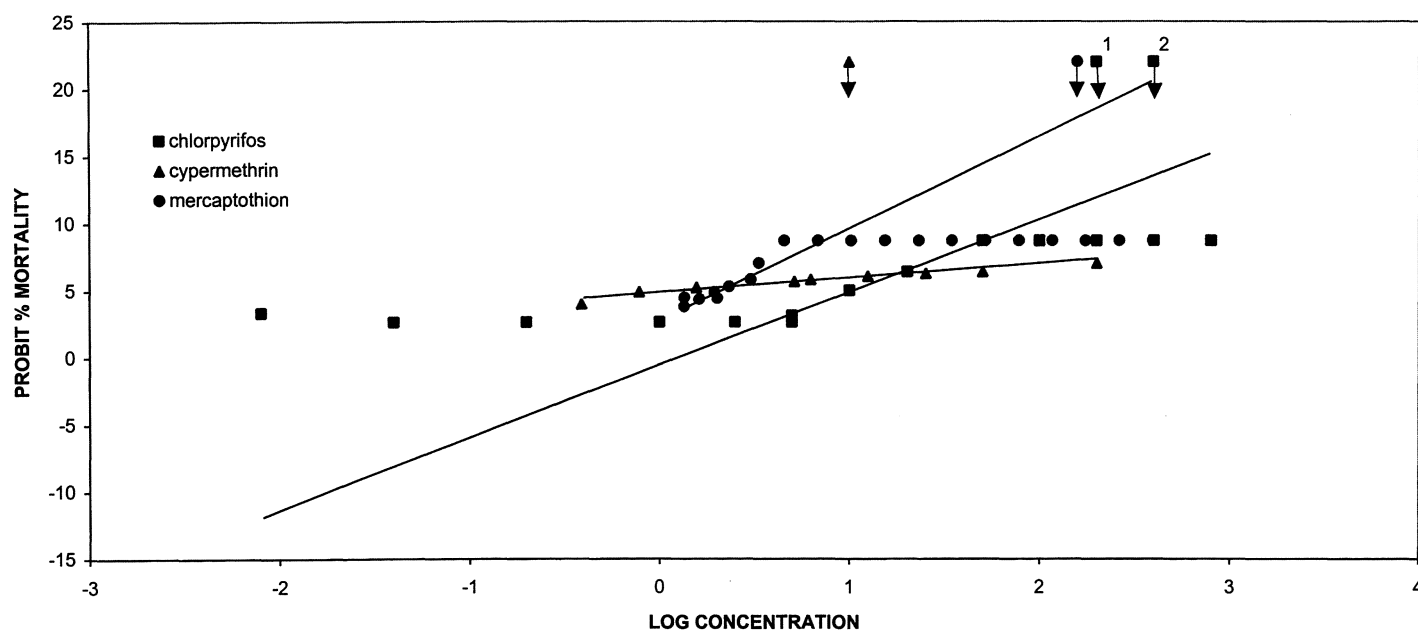


FIGURE 1

Probit mortality on log concentration for the insecticides chlorpyrifos, cypermethrin and mercaptothion. The field concentrations are indicated with arrows (■¹ for mealybugs, and ■² for ants).

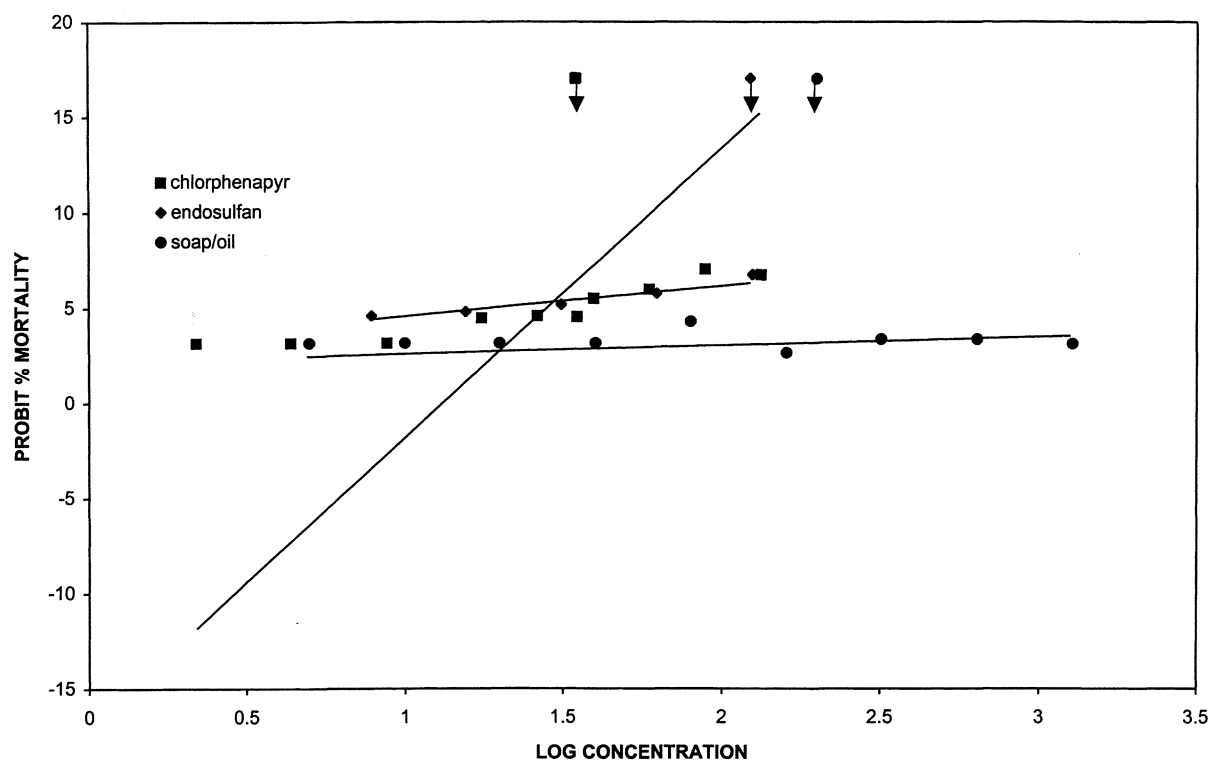


TABLE 3

Field concentrations, LC₅₀, and LC₉₀ of the pesticides tested on *Nephus 'boschianus'* the mealybug predatory beetle.

Chemical	Field dose mL/100L	LC ₅₀ (mL/100L)	95% Fiducial limits	LC ₉₀ (mL/100L)	95% Fiducial limits
chlorpyrifos	400 (ants) 100-200 (mealybug)	10.48	9.3 – 11.8	18.1	15.9 – 21.6
endosulfan	125	18.67	11.4 – 26.7	118.61	70.5 – 345.4
cypermethrin	10	1.26	0.7 – 2	19.54	11.7 – 41.4
chlorfenapyr	35	33	27.2 – 39.4	76.97	60.8 – 113.3
mercaptothion	175	2.14	2 – 2.2	3.28	3.1 – 3.6
soap plus oil	20mL + 2mL	0.22 + 7	–	0.15 + 10	–
mancozeb	200	–	–	–	–
fosetyl-Al	350g	–	–	–	–
penconazole	30 – 45	0.16 + 7	–	0.14 + 10	–

Chlorpyrifos is a broad spectrum, relatively persistent insecticide. Its effect can be countered if applied as a spot and stem barrier treatment against ants (Ueckermann, 1998). In this way it will reduce its effect on the predator. Additionally, the high numbers of *N. 'boschianus'* present in early summer (October to December) will not be affected if chlorpyrifos cover sprays are applied prior to budding (July to August) as recommended for *P. ficus* control.

The mercaptothion bait mixture was more toxic to *N. 'boschianus'* than chlorpyrifos (Table 3; Fig.1). The current practice of fruit-fly bait sprays during the season is thought to cause minimal harm to beneficial organisms. *N. 'boschianus'* beetles, however, consume any moisture available on vines, especially during the hot summer months (Whitehead, pers. com., 2000). This need could, however, result in these beetles being attracted to this mixture to its detriment.

The field concentrations at which endosulfan and chlorfenapyr are used were just above the LC₉₀ values (Table 3; Fig. 2). These concentrations were therefore not as detrimental as chlorpyrifos to *N. 'boschianus'*. Both chemicals, however, have a broad spectrum of activity, suggesting that their use in insect pest management systems should be kept to a minimum. A full cover application of endosulfan during summer against erinose mite, and of chlorfenapyr early in the season against Western flower thrips (Nel *et al.*, 1999), will therefore probably influence *N. 'boschianus'* populations negatively.

Cypermethrin was slightly less toxic to *N. 'boschianus'* than chlorpyrifos, with the field concentration higher than the LC₅₀, but lower than the LC₉₀ (Table 3; Fig. 1). Cypermethrin is registered for use on weevils throughout the season (Nel *et al.*, 1999). Full cover applications of cypermethrin during the season will probably also be detrimental to *N. 'boschianus'* populations.

The soap plus oil mixture, an organic pesticide to be registered shortly, had no impact on *N. 'boschianus'*. Both the LC₅₀ and

LC₉₀ values were much higher than the proposed field dose (Table 3; Fig. 2). This pesticide could contribute to integrated pest management in vineyards should field data prove efficacy against vine mealybug.

The LC₅₀ value of penconazole (Table 3; Fig. 3) was much higher than the field concentration (Nel *et al.*, 1999) and it should therefore not be detrimental to *N. 'boschianus'*. Mancozeb and fosetyl-Al also did not appear to be detrimental to *N. 'boschianus'*, as there was no increase in mortality of the predator with increasing concentrations of these fungicides (Fig. 3).

CONCLUSIONS

When applied as cover sprays the insecticide chlorpyrifos and the mercaptothion bait mixture were highly toxic to *N. 'boschianus'*, whilst endosulfan, chlorfenapyr and cypermethrin were less toxic. The soap plus oil mixture had no effect on *N. 'boschianus'*, while the fungicides penconazole, fosetyl-Al and mancozeb should also not affect *N. 'boschianus'* populations. Further field confirmation of these results are needed before final conclusions can be made concerning the effect of these chemicals on *N. 'boschianus'*.

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